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**Space Weather Technical Forecast**

Issued on Wednesday, 06 December 2023 at 12:54 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

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**Space Weather Forecast Headline: Chance of further isolated M-Class flares (R1-R2 Blackouts) throughout. Chance of Active fluence Days 3-4 (08-09 Dec).**

**Analysis of Space Weather Activity over past 24 hours**

**Solar Activity:** Solar activity is currently Moderate with two M-Class flares in the past 24 hours, with a peak M2.1 at 06/0541 UTC which originated from AR3513 in the northeast. There are currently 9 sunspot regions on the visible disc. The most active region on the disc is AR3513. The viewing angle of this region is improving, showing some magnetic complexity with a hint of a delta spot, although this is not yet confirmed. Two other larger regions on the disc are AR3510 and AR3511 close to centre disc in the south. There is a complex of regions in this area, with magnetic connection between these regions. AR3507 has developed a weak delta spot, and has more of a north-south magnetic alignment, perhaps increasing instability. The other regions on the disc appear mostly smaller and simpler at present, although a new region south of AR3513 is still difficult to see near the limb and is starting to show greater area. This may be more complex than the current classification.

A number of CMEs have been evident in coronagraph imagery during the past 24 hours. A filament eruption from the north centre disc starting around 06/0430 UTC may produce a CME, although nothing has yet appeared in coronagraph imagery. An earlier filament eruption around 05/2130 UTC seems to be mostly northward directed and is less likely to reach Earth.

**Solar Wind / Geomagnetic Activity:** Solar winds as measured by ACE and DSCOVR at L1 show an ongoing High Speed Stream (HSS) from coronal hole CH76/-. Wind speeds have been at elevated to strong levels, mostly just above 600 km/s. Density has been below average throughout. The Interplanetary Magnetic Field (IMF), Bt, has been weak throughout at 6nT or below. The north-south component of the IMF (Bz), has varied weakly. Phi angle has been predominantly negative (towards the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 2-3).

**Energetic Particles / Solar Radiation:** GOES16 high energy (greater than 10MeV) proton flux remained at background levels. GOES16 high energy (greater than 2MeV) electron flux has been mostly background with a slight increase towards moderate levels in recent hours. The associated 24-hour fluence has remained below the Active threshold (1e8 integrated pfu) with a slight, steady upwards trend. The observation at 06/0000 UTC was 2.16e6 integrated pfu.

**Four-Day Space Weather Forecast Summary**

**Solar Activity:** Solar activity is expected to be Low to Moderate with a chance of further M-class flares, mainly from AR3513, but perhaps also AR3507, AR3510 or AR3511.

**Solar Wind / Geomagnetic Activity:** The CME produced by a filament eruption around 04/0700 UTC is expected to miss Earth, however, there is a very slight chance of a glancing blow late Day 1 (06 Dec) or early Day 2 (07 Dec). A CME visible on recent coronagraph imagery towards the northwest is now considered likely to miss Earth. A further filament eruption near north centre disc was observed starting around 06/0430 UTC, but so far nothing has appeared in

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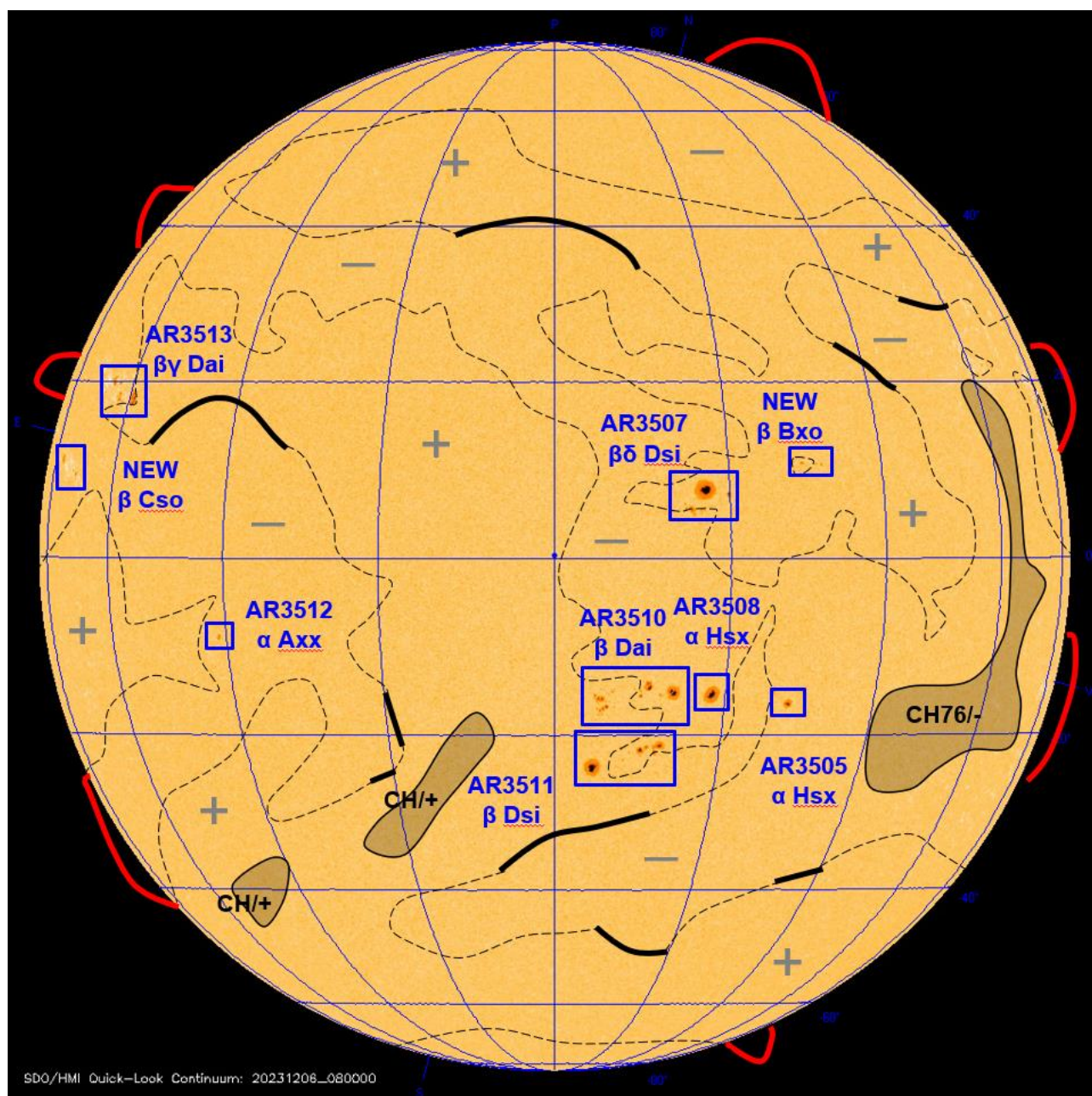
coronagraph imagery. Solar winds are currently at strong levels (around 600 km/s) due to the ongoing HSS from CH76/-. Solar winds are expected to gradually decline through the coming days, with speeds likely to be near background levels by Day 4 (09 Dec).

Geomagnetic activity is expected to be largely Quiet to Unsettled (Kp 0-3). There is a very slight chance late Day 1 or early Day 2 that a glancing blow from a CME may produce an Active (Kp 4) or G1/Minor Geomagnetic Storm interval (Kp 5) but this is considered a low probability.

**Energetic Particles / Solar Radiation:** GOES16 high energy proton flux is forecast to remain at background levels, with just a slight chance of reaching the S1/Minor Storm level should there be any larger flares from the regions near centre disc, or in the short term from AR3500 which is just over the west limb. .

Electron flux is currently increasing to moderate levels. An increase in flux, perhaps reaching high levels at the diurnal maxima, is possible through the next couple of days. There is a chance of the fluence exceeding the Active threshold into Day 3 or Day 4 (08-09 Dec).

Figure 1. Solar Analysis Valid 06/0800 UTC.



**Key:** Filament \_\_\_\_, Prominence \_\_\_\_, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson  $\alpha$ - $\beta$ - $\beta\gamma$ - $\beta\gamma\delta$  and Zurich-McIntosh Axx etc.

**Geomagnetic Storms:**

The CME produced by a filament eruption around 04/0700 UTC is expected to miss Earth, however, there is a very slight chance of some enhancement and a glancing blow late Day 1 (06 Dec) or early Day 2 (07 Dec). A CME visible on recent coronagraph imagery is likely to have originated from a filament lift-off observed leaving the northwest disc around 05/2100 UTC. This is now considered likely to miss Earth. A further filament eruption near north centre disc was observed starting around 06/0430 UTC, but so far nothing has appeared in coronagraph imagery.

Solar winds are currently at strong levels (around 600 km/s) due to the ongoing HSS from CH76/-. Enlil is currently providing good guidance on wind speeds. This coronal hole is a persistent feature and similar in size and position to the previous rotation. However, during the previous solar rotation a CME arrival masked the initial influence of the HSS. Solar winds are expected to gradually decline through the coming days, with speeds likely to be near background levels by Day 4 (09 Dec).

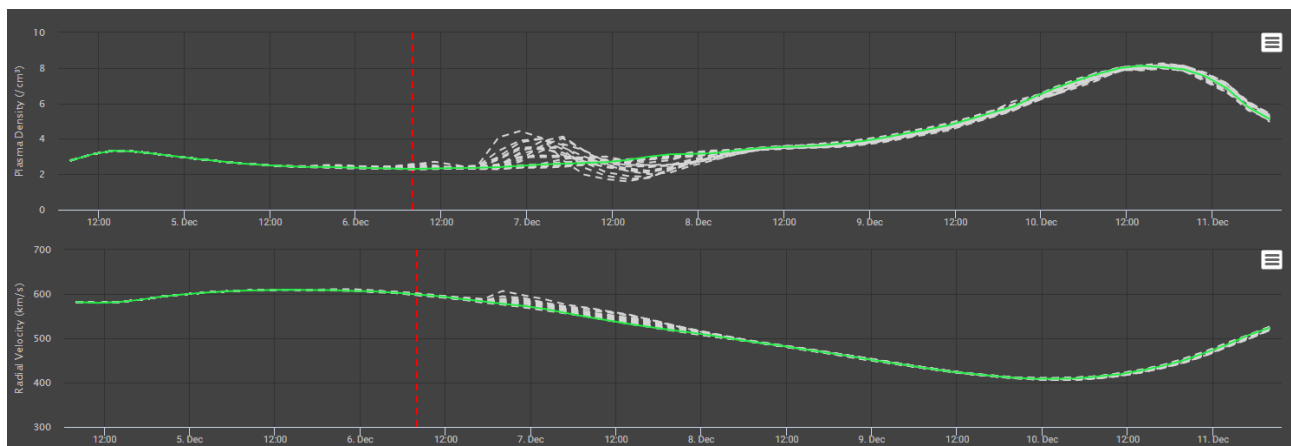
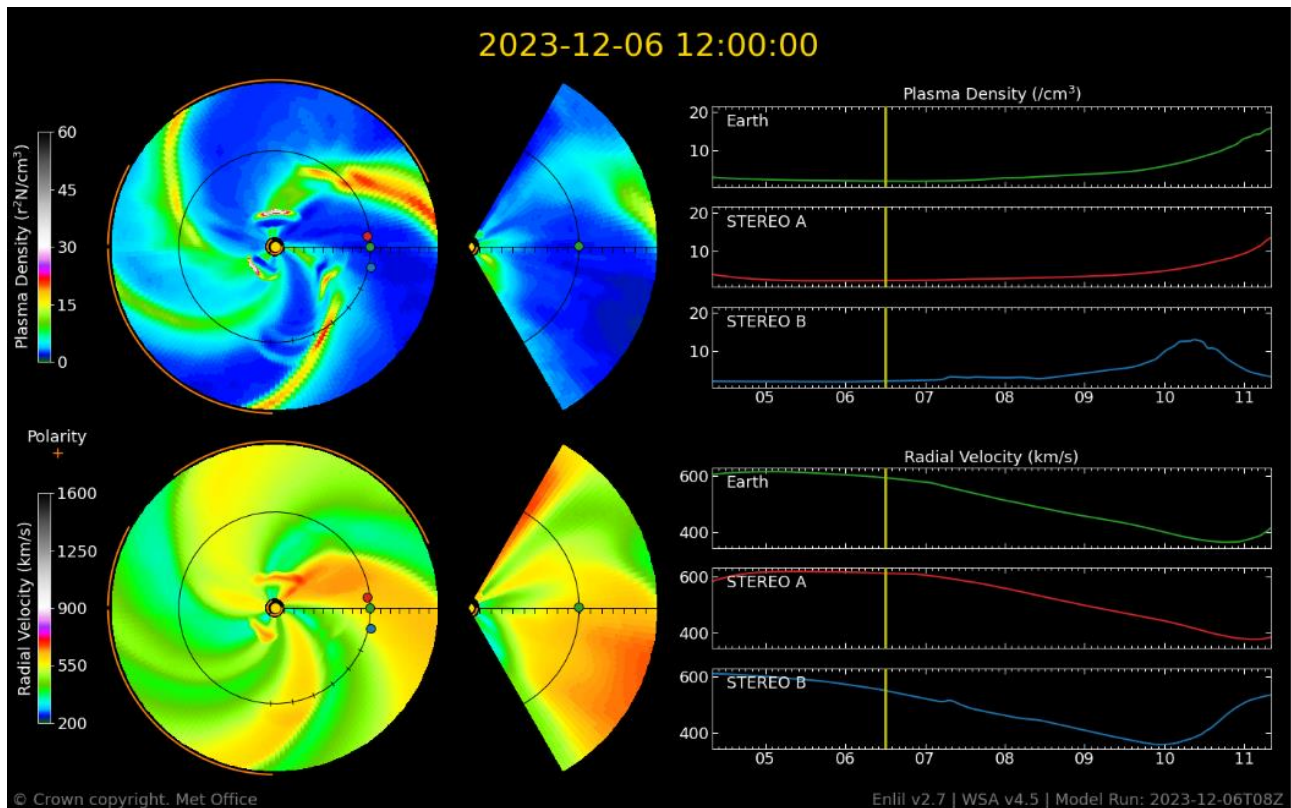
Geomagnetic activity is expected to be largely Quiet to Unsettled (Kp 0-3). There is a very slight chance late Day 1 or early Day 2 that a glancing blow from a CME may produce an Active (Kp 4) or G1/Minor Geomagnetic Storm interval (Kp 5) but this is considered a low probability, with the majority of Enlil ensemble members modelling a clear miss.

| Geo-Magnetic Storm       | Level    | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|--------------------------|----------|------------------------|-------------------|-------------------|-------------------|-------------------|
| Probability (Exceedance) |          |                        | (%)               | (%)               | (%)               | (%)               |
| Minor or Moderate        | G1 to G2 | No                     | 5                 | 5                 | 1                 | 1                 |
| Strong                   | G3       | No                     | 1                 | 1                 | 1                 | 1                 |
| Severe                   | G4       | No                     | 1                 | 1                 | 1                 | 1                 |
| Extreme                  | G5       | No                     | 1                 | 1                 | 1                 | 1                 |

**Geomagnetic Activity - Earthbound Coronal Mass Ejections**

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source               | Source Location | Estimated Speed | Estimated Arrival Time | Comments                          |
|-----------------------|-----------------------|----------------------|-----------------|-----------------|------------------------|-----------------------------------|
| 04/1222               | Partial               | Filament near AR3511 | SE              | 630 km/s        | 07/0500 UTC            | Low confidence of a glancing blow |

**Figure 2: MOSWOC Enlil and ensemble, showing a risk of a CME glancing blow in the next 24 hours. Enlil wind speeds look to be good guidance, showing the HSS waning.**



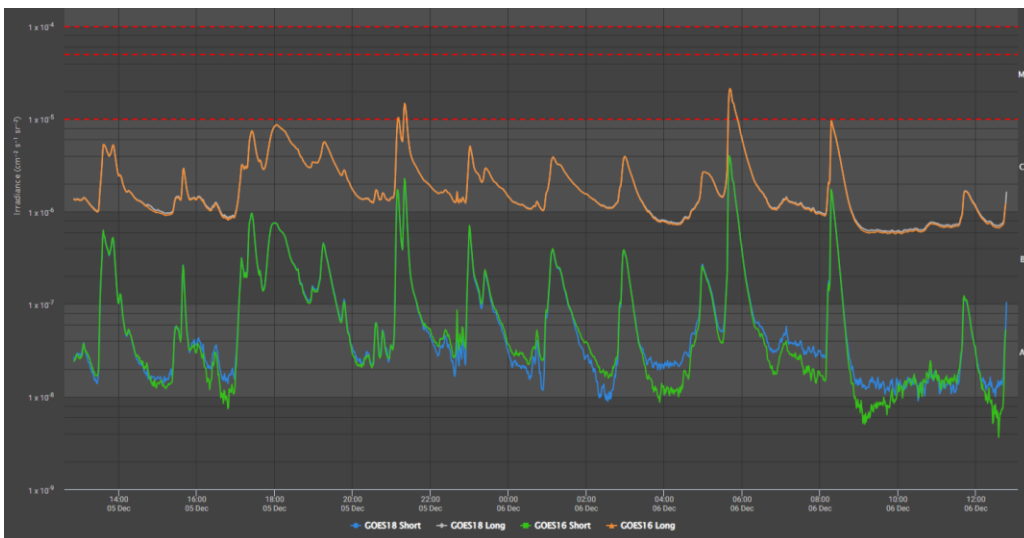
## Radio Blackouts - X-Ray Flares:

There are currently 9 sunspot regions on the visible disc. The most active region on the disc is AR3513 (Dai/Beta-Gamma) in the northeast. The viewing angle of this region is improving, showing some magnetic complexity with a hint of a delta spot, although this is not yet confirmed. Two other relatively complex regions on the disc are AR3510 (Dai/Beta) and AR3511 (Dsi/Beta) close to centre disc in the south. There is a complex of regions in this area, with magnetic connection between these regions. AR3507 (Dsi/Beta-Delta) has developed a weak delta spot, and has more of a north-south magnetic alignment, perhaps increasing instability. The other regions on the disc appear mostly smaller and simpler at present, although a new region south of AR3513 is still difficult to see near the limb and is starting to show greater area. This may be more complex than the current classification.

Solar activity is currently Moderate with the largest flare of the past 24 hours an M2.1 at 06/0541 UTC, which originated from AR3513. Low to Moderate activity is expected to continue with a chance of further isolated M-flares, mainly from AR3513, but perhaps also AR3507, AR3510 or AR3511. No significant regions are expected to rotate off the disc in the next four days, and far side seismographs are not showing any large regions due to rotate onto the disc. As such, the flare probability has been kept flat through the next few days.

| X Ray Flares | Level            | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|--------------|------------------|------------------------|-------------------|-------------------|-------------------|-------------------|
| Probability  |                  |                        | (%)               | (%)               | (%)               | (%)               |
| Active       | R1-R2 M Class    | Yes                    | 50                | 50                | 50                | 50                |
| Very Active  | R3 to R5 X Class | No                     | 5                 | 5                 | 5                 | 5                 |

**Figure 3: X-ray trace at GOES16 and GOES18, showing two M-class flares, both from AR3513**



## Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at background levels and is most likely to remain so in the next few days. There is a slight chance of S1/Minor Storm conditions being reached should any significant flares occur, mainly from AR3510 and AR3511 as they rotate further across the western disc. There is also a lingering risk from AR3500 which is now over the western limb, but this risk reduces as it rotates well away from the limb.

| Radiation Storms                                                                                                | Level<br>(cm <sup>-2</sup><br>sr <sup>-1</sup> s <sup>-1</sup> ) | Past 24<br>Hours<br>(Yes/No) | Day 1<br>(00-24 UTC) | Day 2<br>(00-24 UTC) | Day 3<br>(00-24 UTC) | Day 4<br>(00-24 UTC) |
|-----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|------------------------------|----------------------|----------------------|----------------------|----------------------|
| Probability<br>(Exceedance)                                                                                     |                                                                  |                              | (%)                  | (%)                  | (%)                  | (%)                  |
| Active                                                                                                          | ≥ S1                                                             | No                           | 10                   | 7                    | 5                    | 5                    |
| Very Active                                                                                                     | ≥ S3<br>*                                                        | No                           | 1                    | 1                    | 1                    | 1                    |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm <sup>-2</sup> sr <sup>-1</sup> s <sup>-1</sup> ) |                                                                  |                              |                      |                      |                      |                      |

## High Energy Electrons Event ( $\geq 2\text{MeV}$ ):

Electron flux is currently rising slightly to moderate levels. The Van Allen belts are still suppressed following recent enhanced geomagnetic activity associated with the HSS from CH76/- and CME glancing blows. An increase in electron flux, perhaps reaching high levels at the diurnal maxima, is possible through the next couple of days as the electron belts relax back towards ambient positions. However, the slight chance of a glancing blow from a CME late Day 1 (06 Dec) or early Day 2 somewhat reduces confidence in the forecast.

The associated 24 hour electron fluence is most likely to increase through the coming days, with a chance of exceeding the Active threshold into Day 3 or Day 4 (08-09 Dec). Current REFM forecast is considered to be providing reasonable guidance.

| GEO Electron Environment | Level ( $\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$ ) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|--------------------------|-----------------------------------------------------------|------------------------|-------------------|-------------------|-------------------|-------------------|
| Probability (Exceedance) |                                                           |                        | (%)               | (%)               | (%)               | (%)               |
| Active                   | $\geq 2 \text{ MeV}$<br>$\geq 1 \times 10^8$              | No                     | 5                 | 10                | 30                | 40                |
| Very Active              | $\geq 2 \text{ MeV}$<br>$\geq 1 \times 10^9$              | No                     | 1                 | 1                 | 1                 | 1                 |

Figure 4: MOSWOC REFM forecasting a rise in fluence above the Active ( $1\text{e}8$  integrated pfu) threshold. This seems like reasonable guidance.

